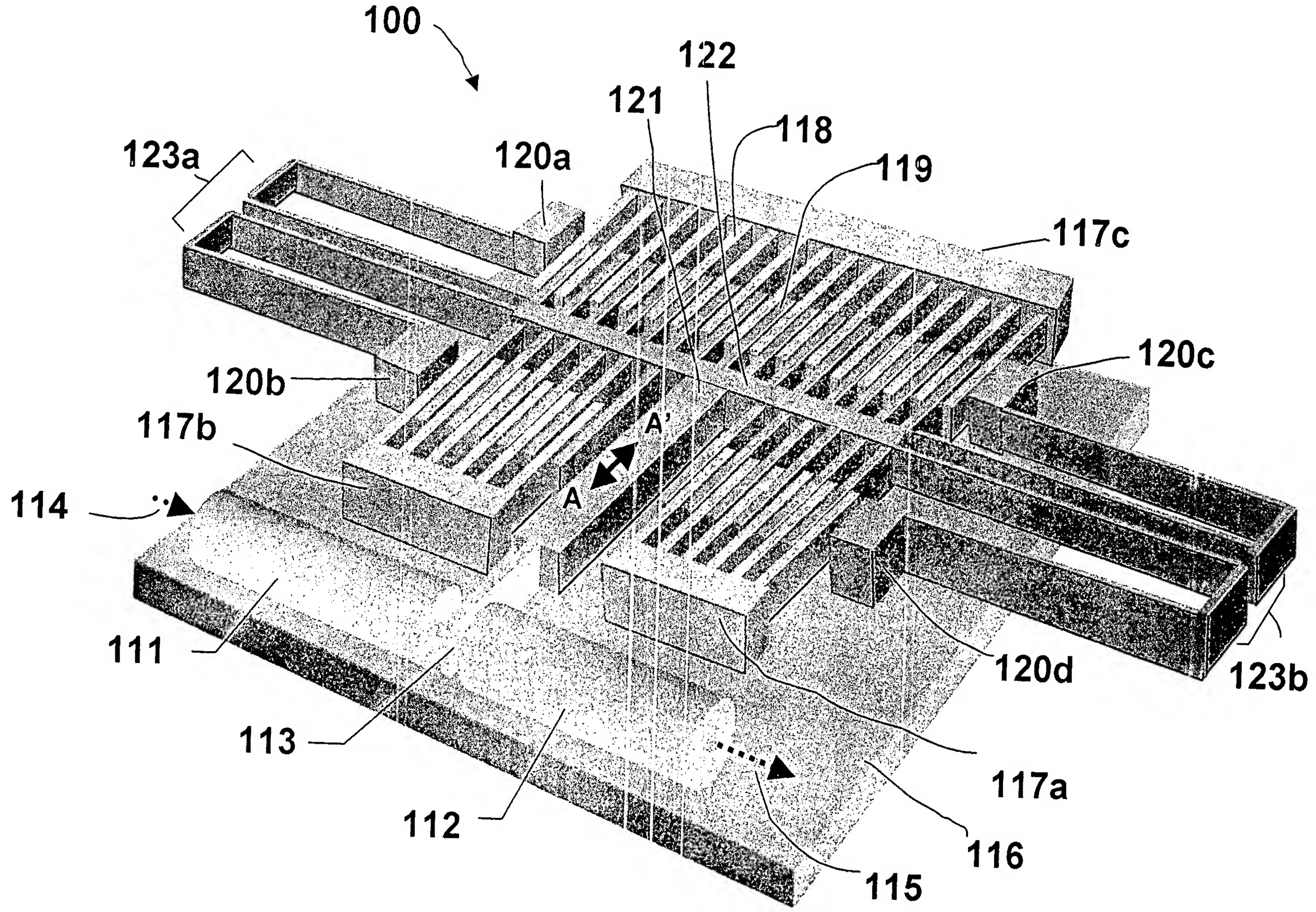
100
122
121
118
119
123a
120a
117c
120c
120b
117b
A'
A
114
111
113
112
120d
123b
117a
116
115

Fig.1

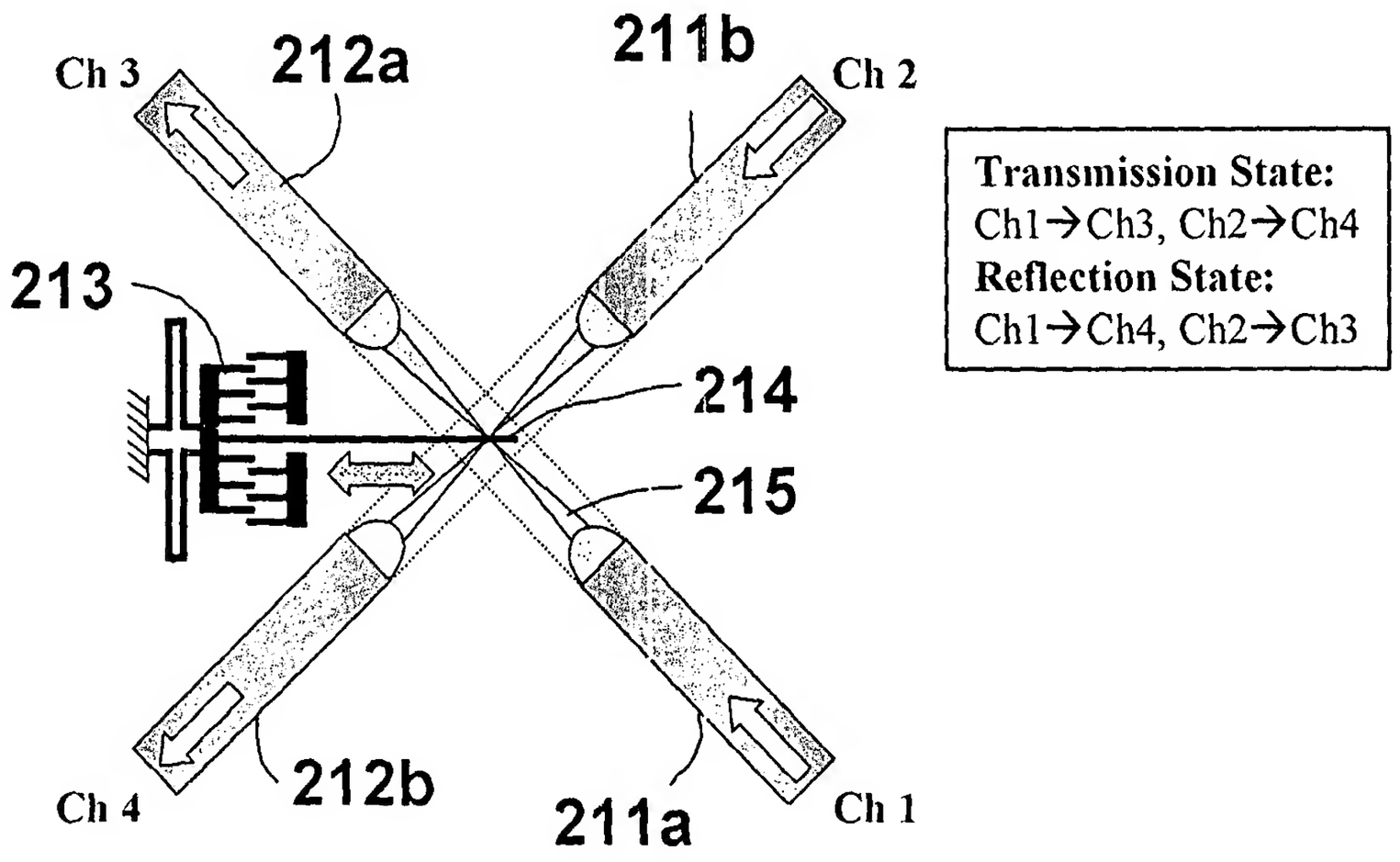
Ch 3
212a
211b
Ch 2
213
214
215
Ch 4
212b
211a
Ch 1
Transmission State:
Ch1→Ch3, Ch2→Ch4
Reflection State:
Ch1→Ch4, Ch2→Ch3

Fig.2

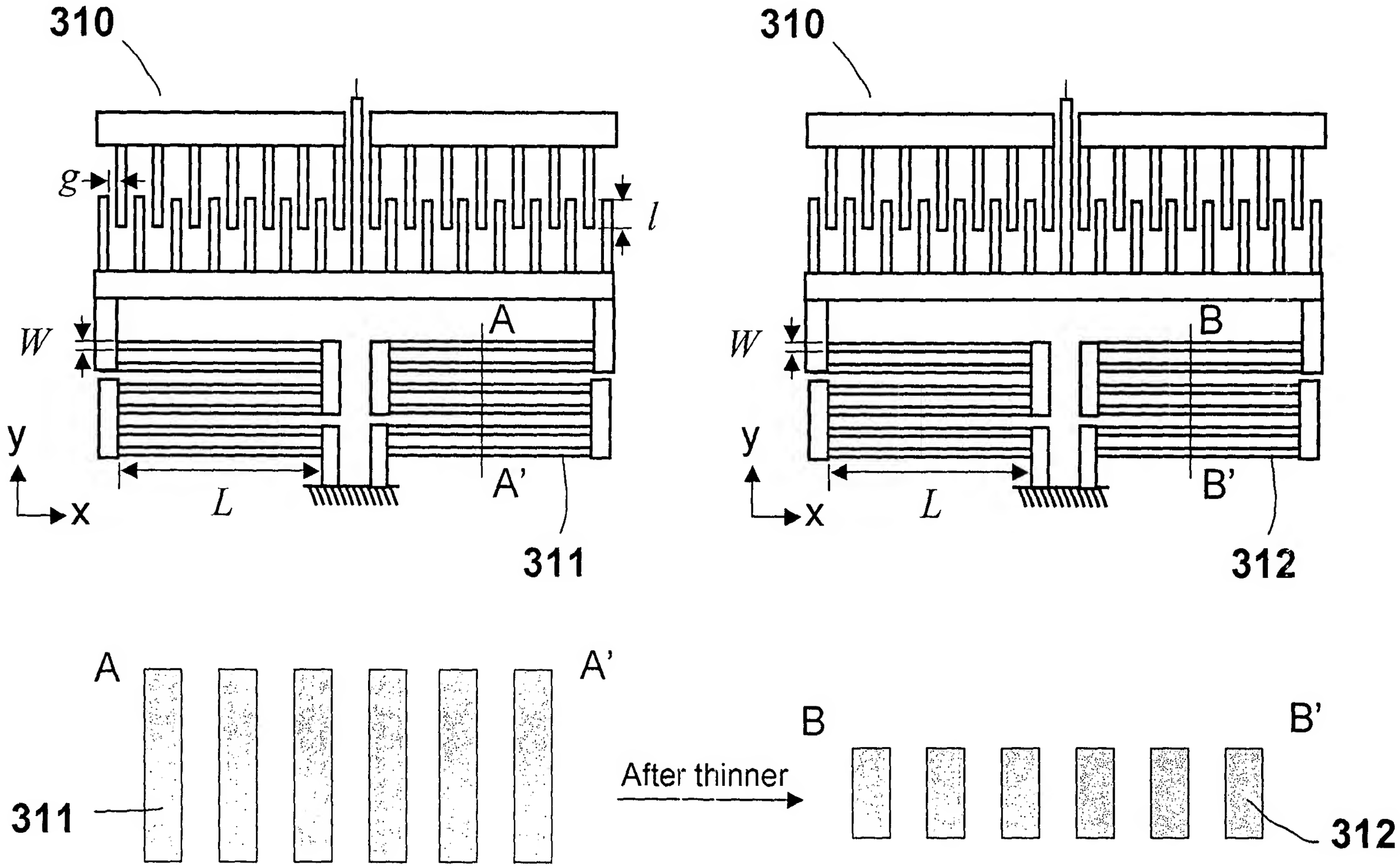

Fig.3

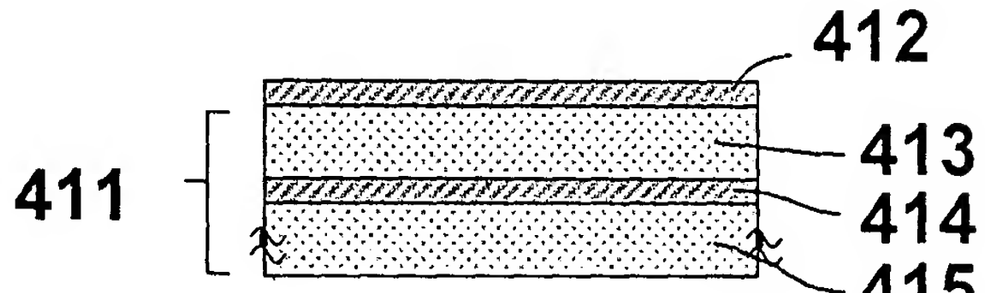

Fig.4a

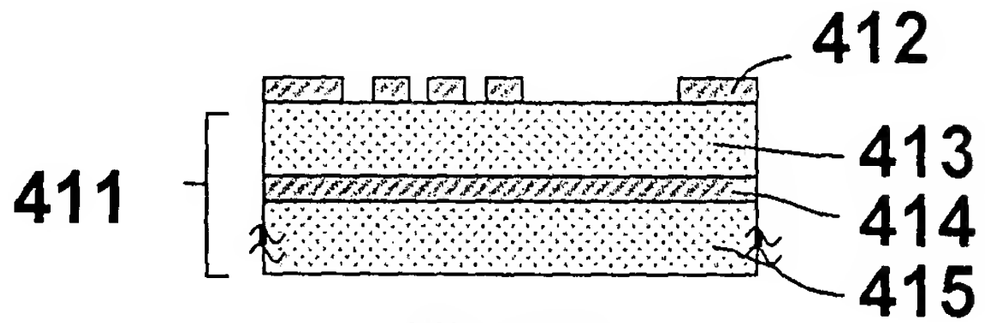

Fig.4b

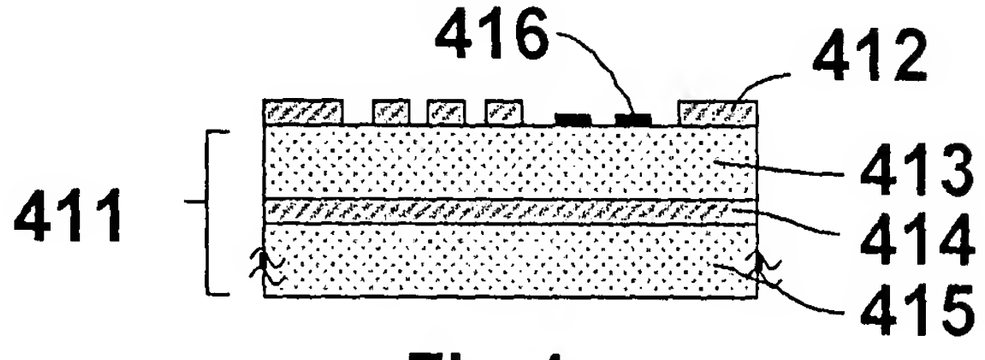

Fig.4c

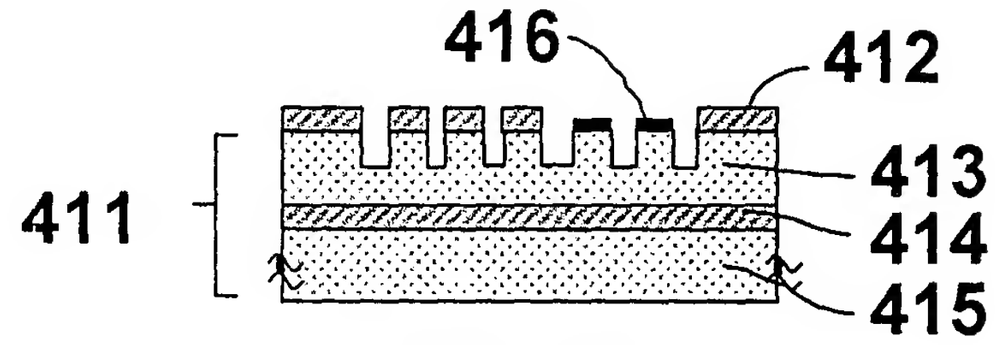

Fig.4d

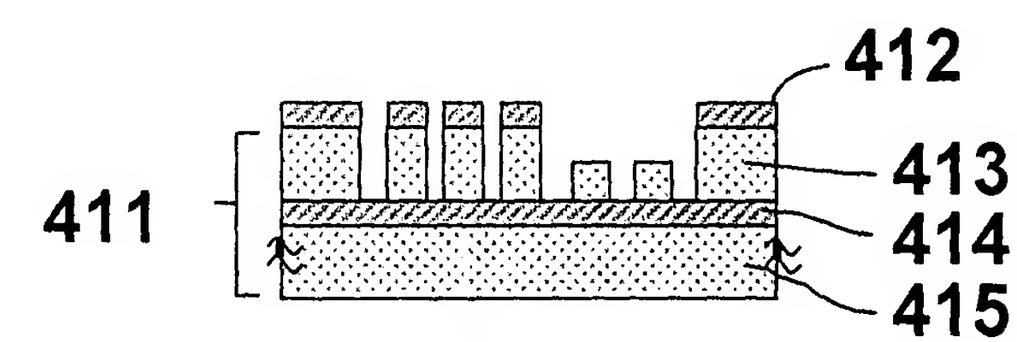

Fig.4e

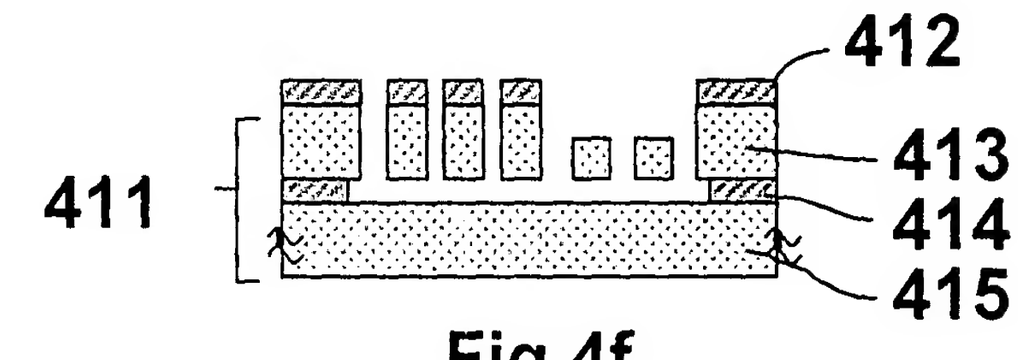

Fig.4f

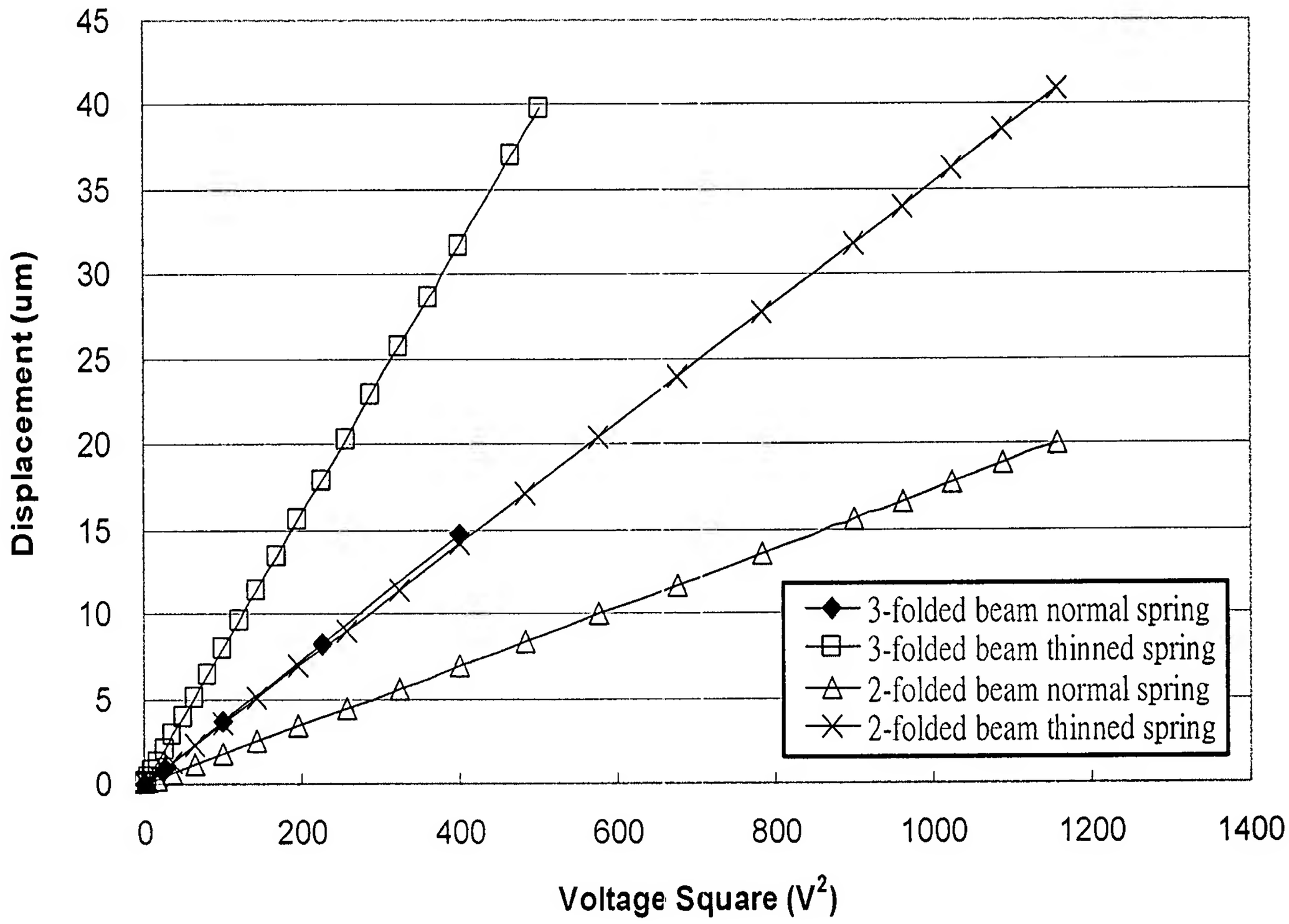
Displacement (um)
45
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
1200
1400
Voltage Square (V2)
3-folded beam normal spring
3-folded beam thinned spring
2-folded beam normal spring
2-folded beam thinned spring

Fig.5

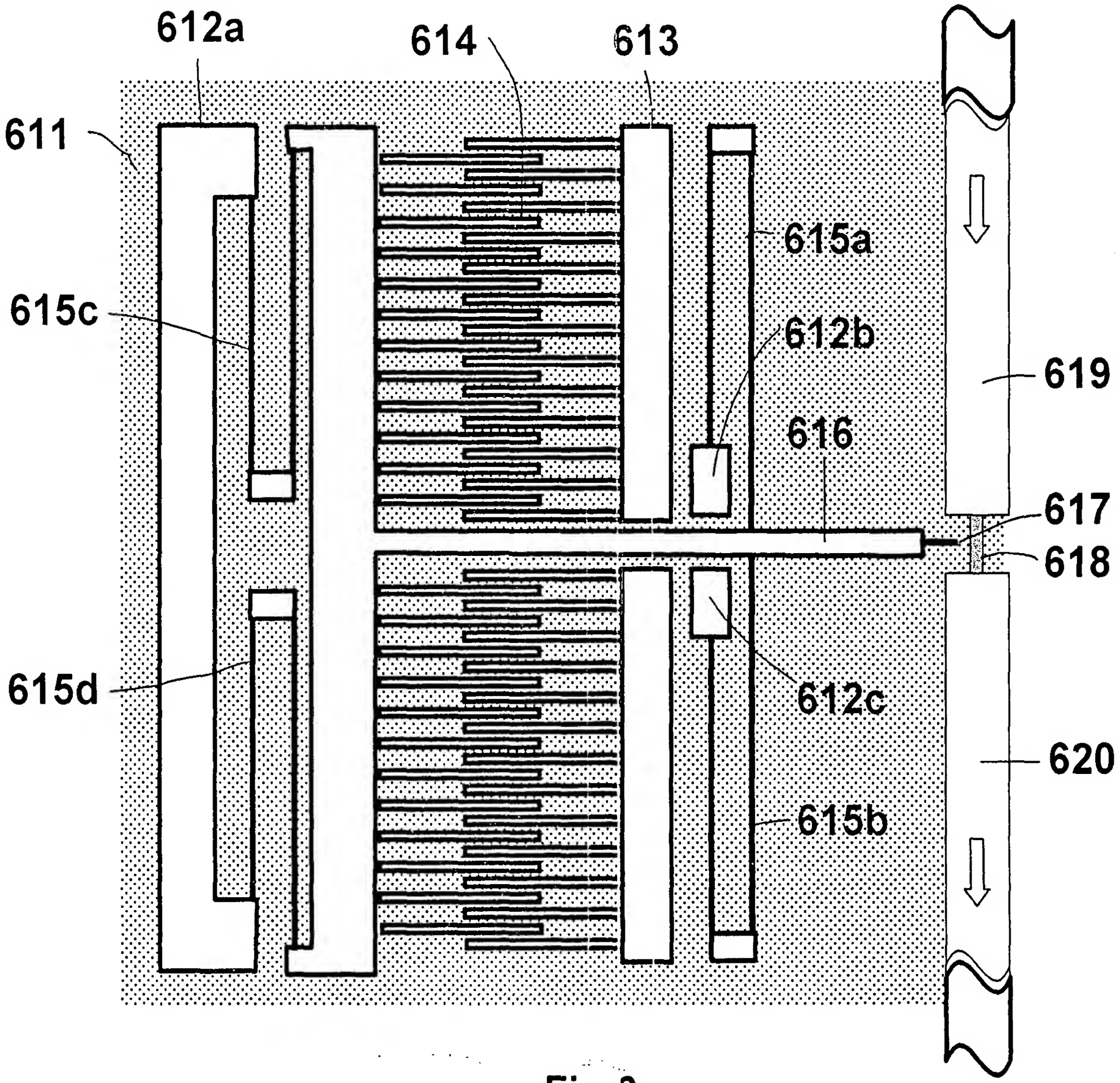
612a
614
613
611
615a
615c
612b
619
616
617
618
615d
612c
620
615b

Fig.6

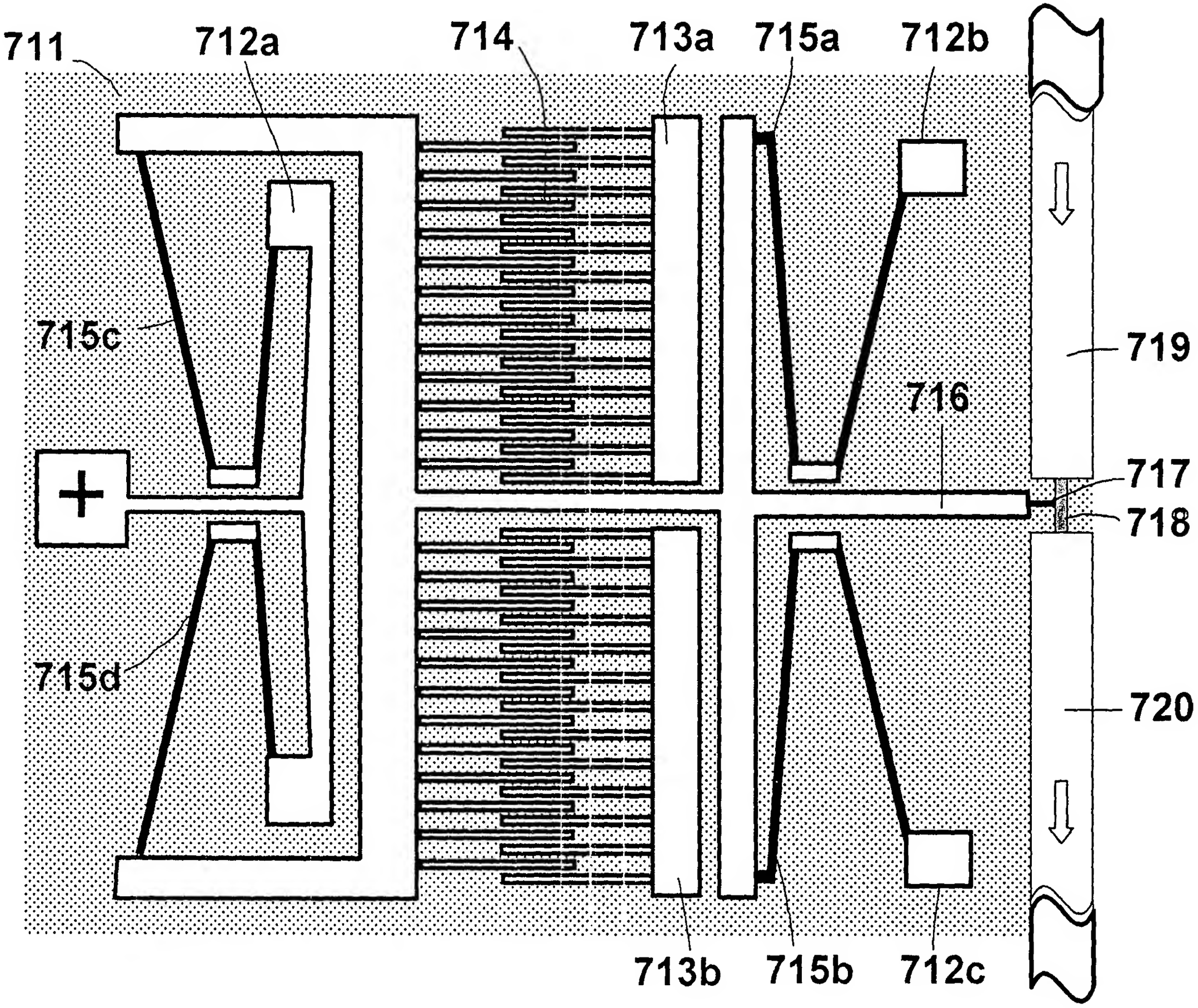
711
712a
714
713a
715a
712b
715c
719
716
717
718
715d
720
713b
715b
712c

Fig.7

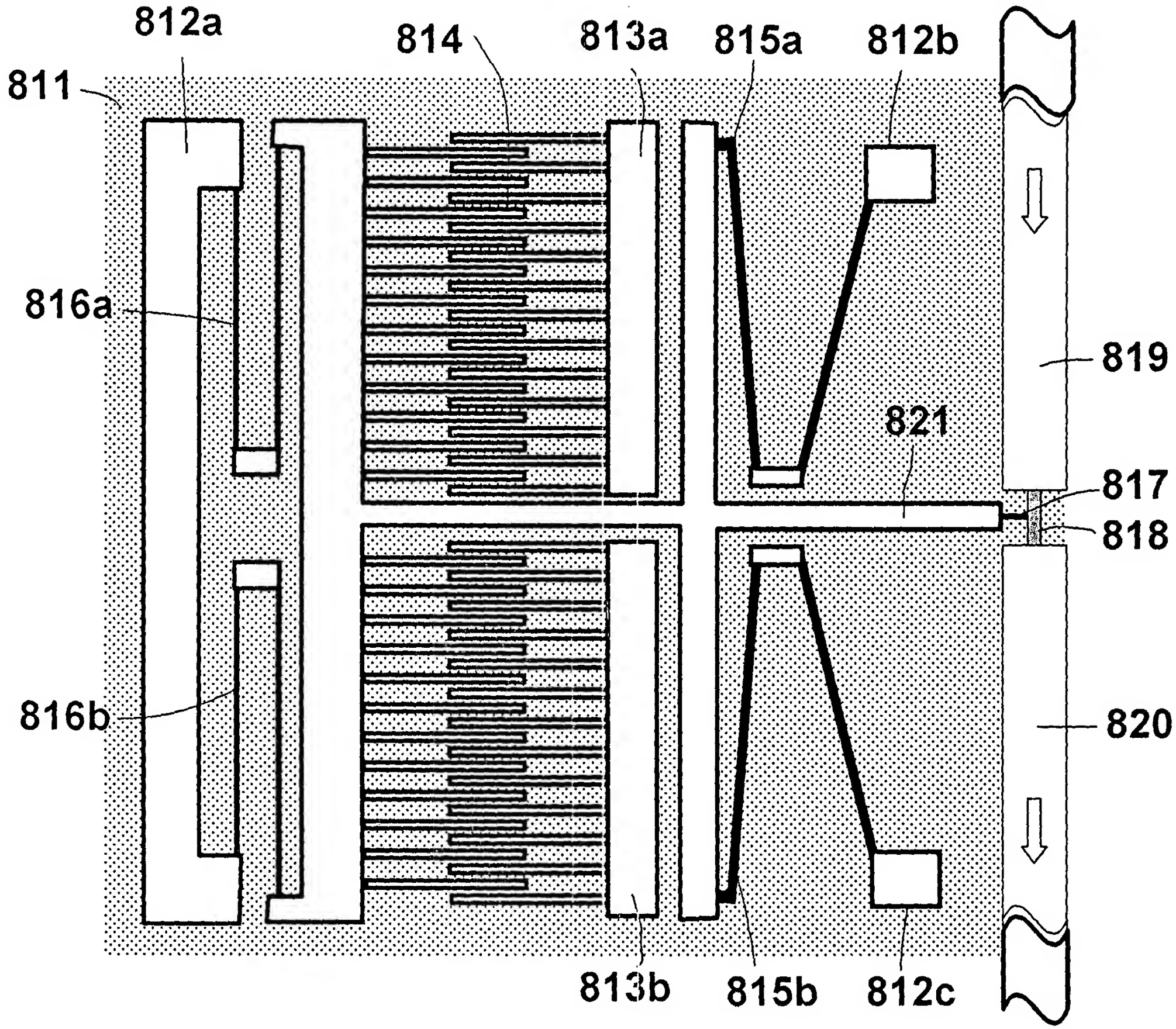
812a
814
813a
815a
812b
811
816a
819
821
817
818
820
816b
813b
815b
812c

Fig.8a

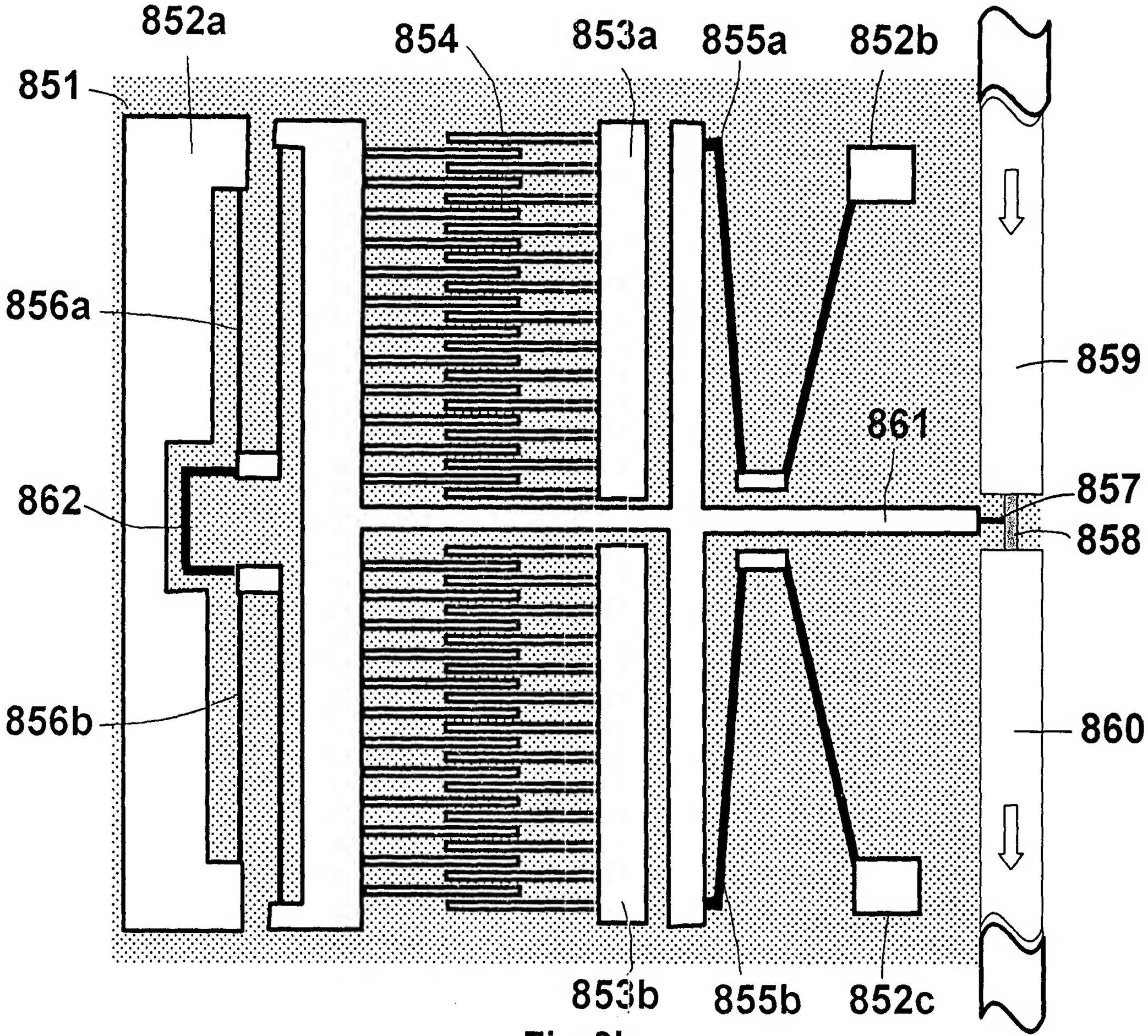
852a
854
853a
855a
852b
851
856a
859
861
862
857
858
856b
860
853b
855b
852c

Fig.8b

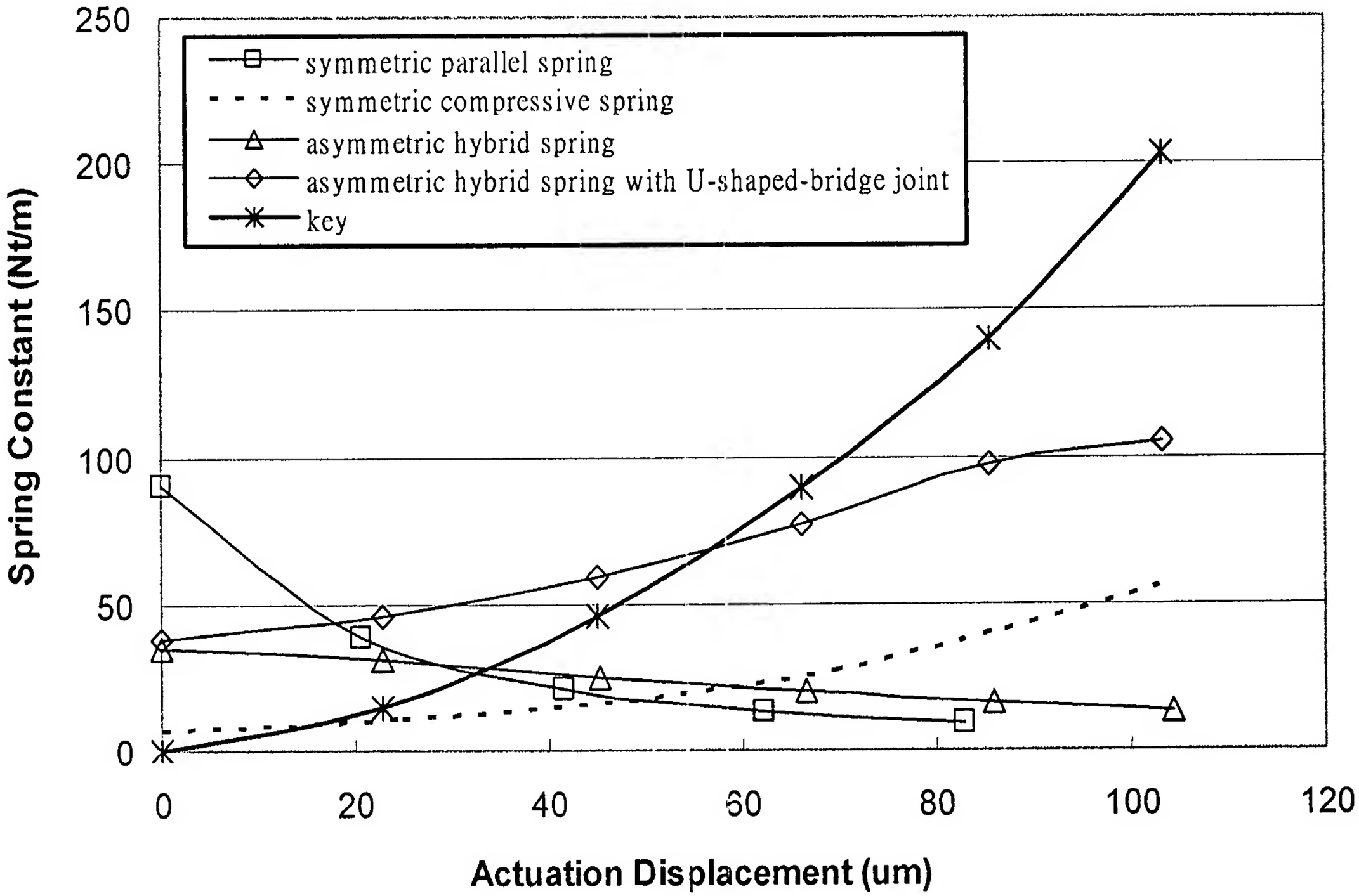
250
200
150
100
50
0
0
20
40
60
80
100
120
Spring Constant (Nt/m)
Actuation Displacement (um)
symmetric parallel spring
symmetric compressive spring
asymmetric hybrid spring
asymmetric hybrid spring with U-shaped-bridge joint
key

Fig.9

$$F = \frac{\varepsilon \cdot t \cdot H \cdot V^2}{2 \cdot g}$$

ε:dielectric constant
H: thickness of device
V: voltage
g : gap of finger
t : width of comb finger

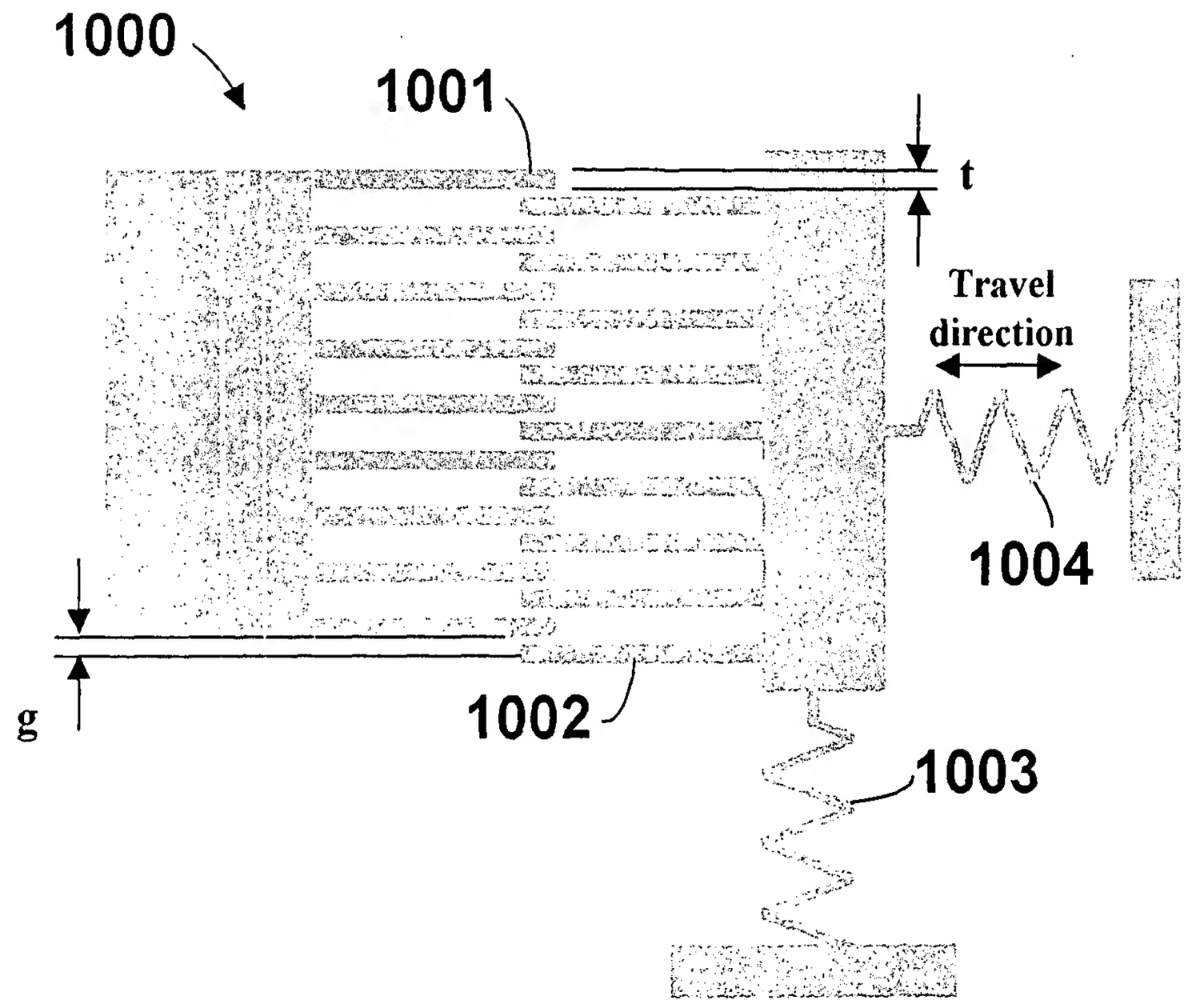

Fig.10a

$$F = \varepsilon \cdot H \cdot V^2 \cdot \frac{\left(g \cdot \cos(\theta) + Wo \cdot \sin(\theta)\right)}{\left(g - x \cdot \sin(\theta)\right)^2}$$

ε:dielectric constant
H: thickness of device
V: voltage
g : gap of finger
Wo :overlap of comb finger
θ : degree of oblique comb
Lo : working distance

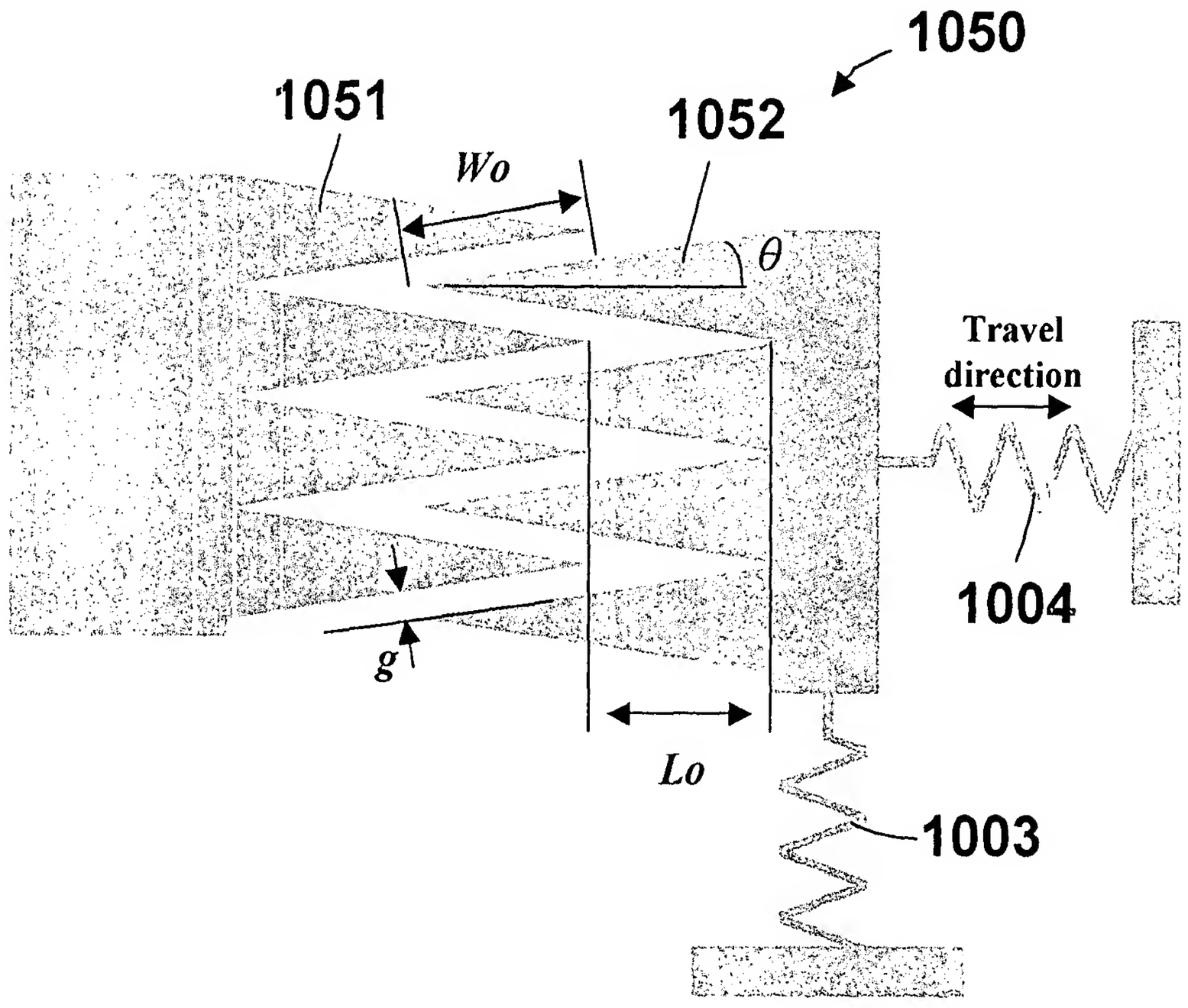

Fig.10b

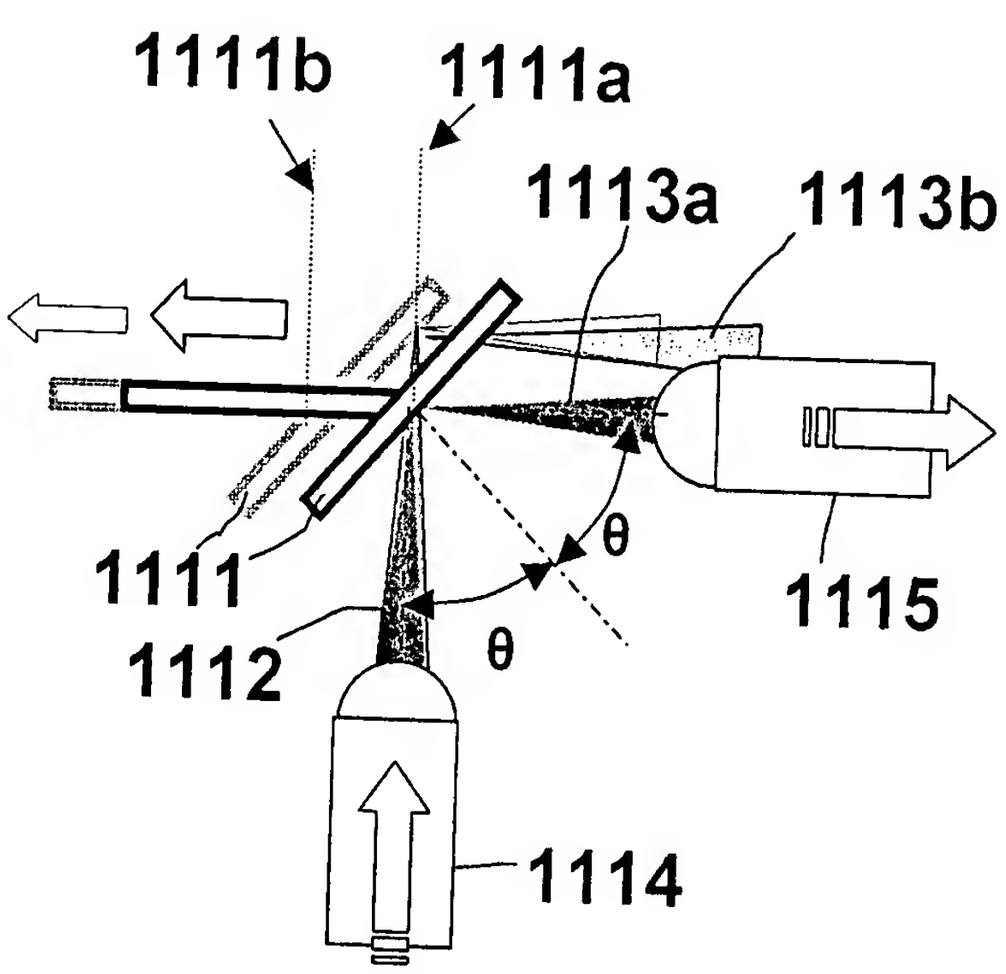

Fig.11a

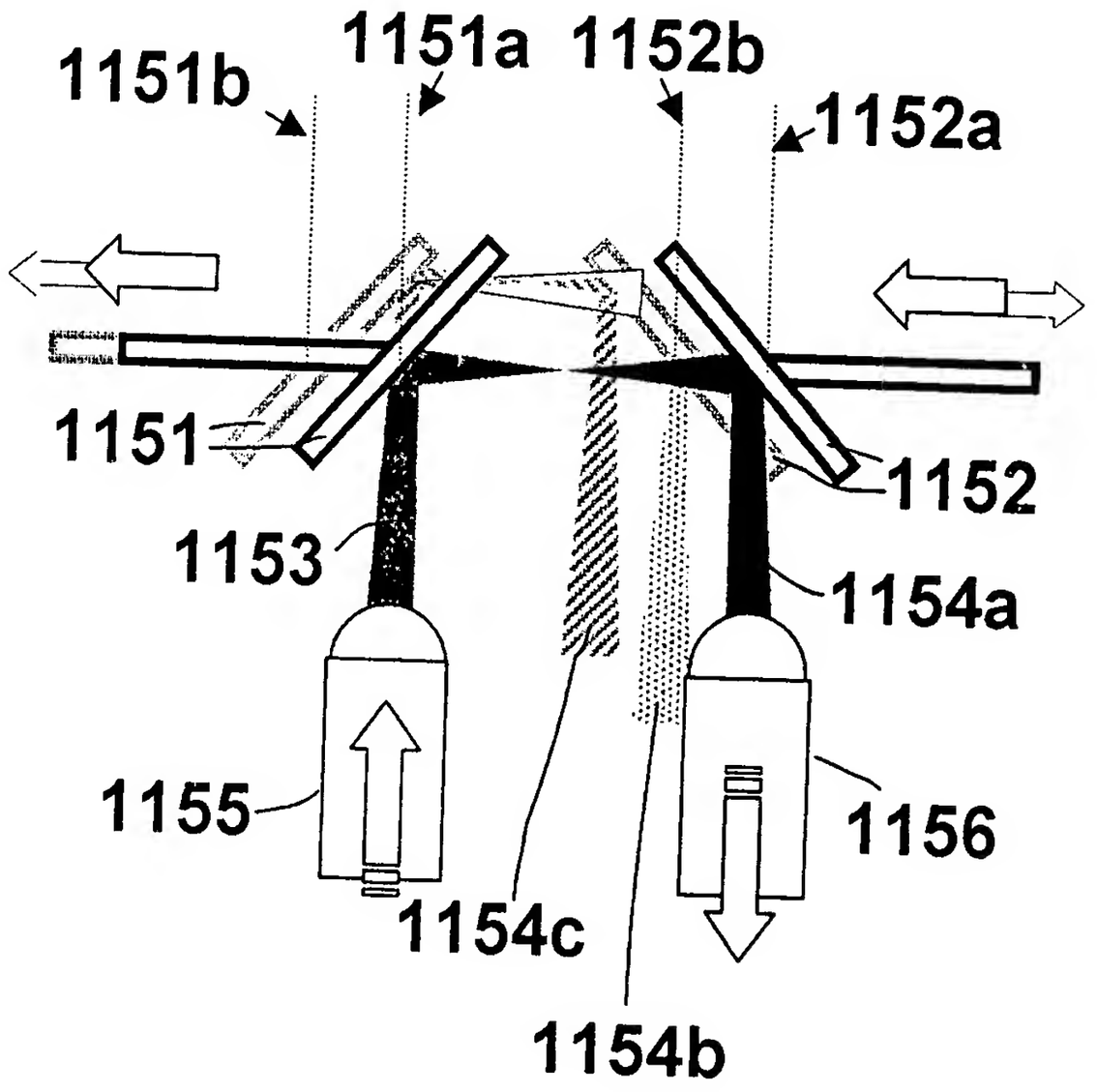

Fig.11b

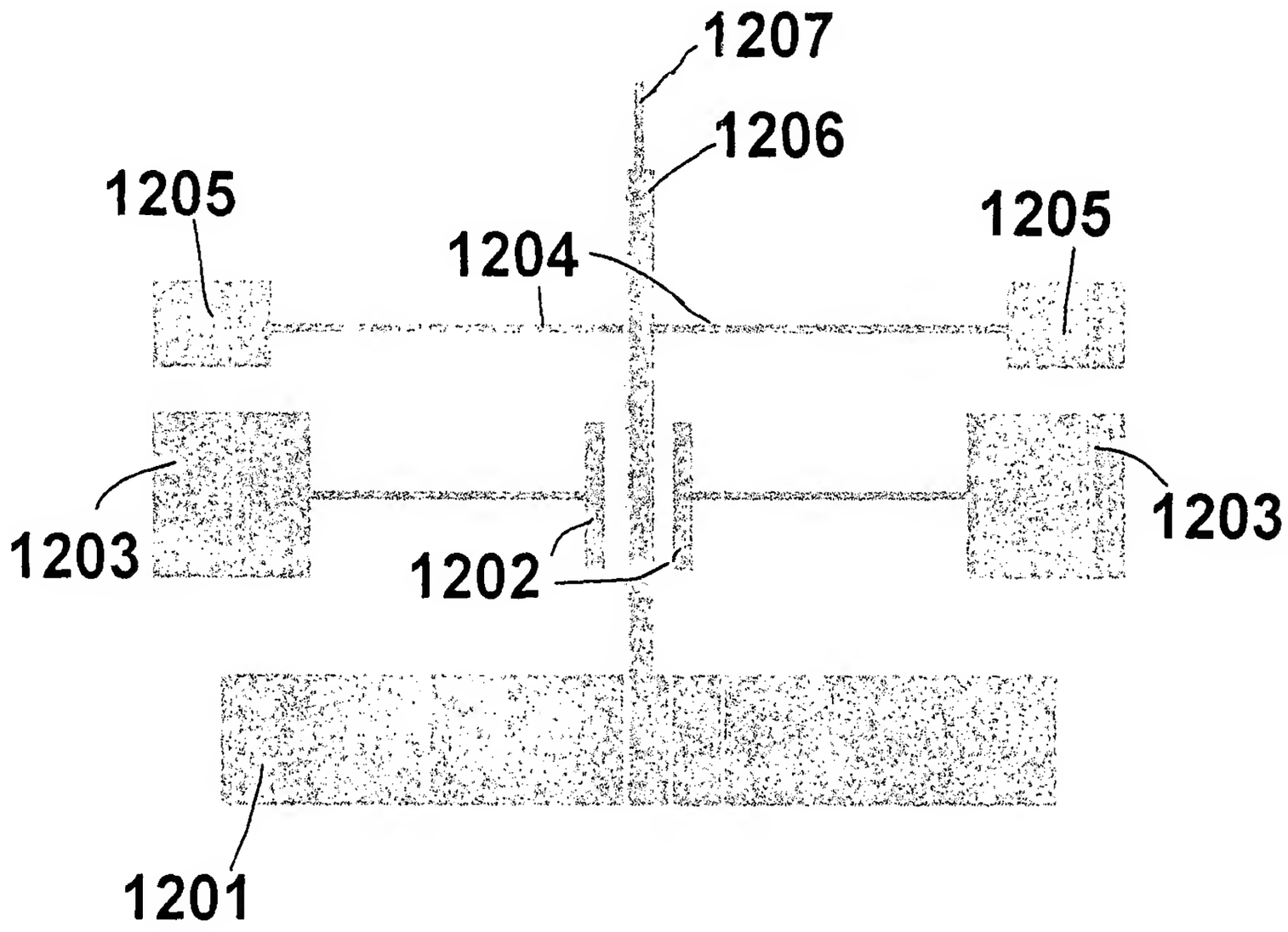

Fig.12a

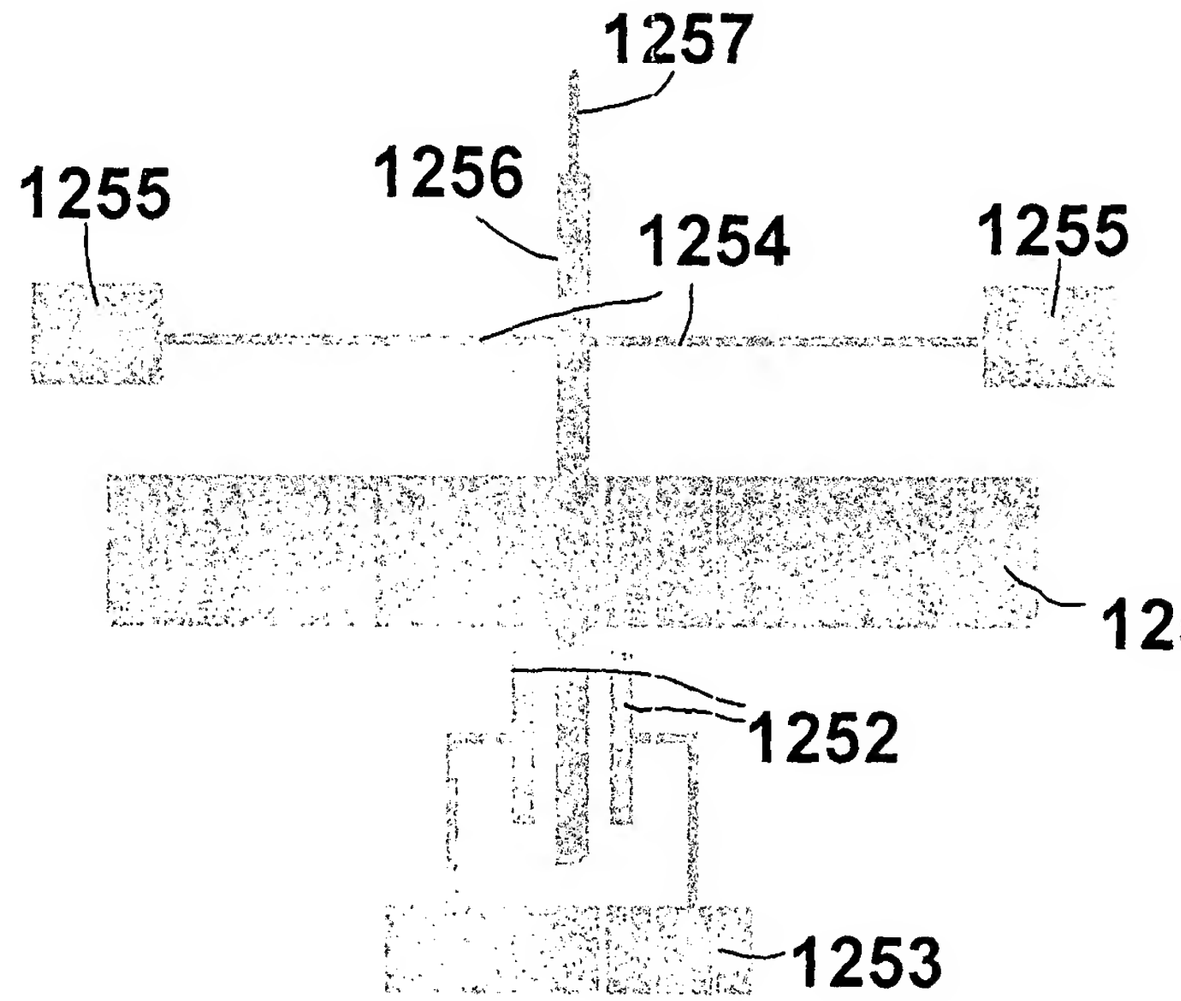

Fig.12b